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The history and general principles of programed instruction are surveyed. Research literature published on the topic is cited and the declining frequency of articles appearing on the subject is noted. Some reasons for the growing use of programed instruction in industry are discussed. A plea for better evaluation measures is made. The use of programed instruction as a teacher aid and as a means of individualized instruction is affirmed. References, data tables, and sample programed frames are included. (BS)

HOW EFFECTIVE IS PROGRAMMED INSTRUCTION IN TEACHING OF READING?

by

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> "Glittering prizes are offered to those who introduce programmed instruction into educational and training situations. There has been no shortage of good reasons why programmed instructions must be, in principle, superior to conventional classroom instruction, and indeed, the first empirical studies in the (British) armed forces seemed to promise drastic improvements in learning rate. More recent work, however, has tended to indicate something nearer parity between programmed instruction on one hand and conventional classroom instruction on the other." (4)

This quotation from Duncan in 1965, speaking about the experiences of the British armed forces in the use of programmed instruction, could fairly well be mirrored by reading teachers who have seriously investigated the use of programmed instruction in the teaching of reading. It is not that programmed instruction cannot teach; there is much evidence to the fact that it can. The difficulty is that teachers expect it to teach better than traditional or conventional methods and this it cannot do, at least with any degree of consistency. But before we go into the problem of effectiveness, let us review some of the principles of programmed instruction which can also serve as a definition of what we are talking about.

PRINCIPLES OF PROGRAMMED INSTRUCTION

Although there is something less than unanimous agreement on the principles involved in a programmed instruction situation, here are some which many would agree upon: (6)

1. The subject matter is broken up into small units called frames. In actual practice, these frames usually vary in size from a short sentence to several small paragraphs.
2. At least part of the frame requires some type of response from the student. He must answer a question or fill in a blank. Active participation on the part of the student is required. Generally, it is desired that the activity also demonstrate understanding of the material.
3. The student is provided immediate feedback reinforcement. He is told the correctness of his answer, which has the advantage of immediately reinforcing the activity or immediately correcting a misunderstanding. Since many programs are written in such a way that the student is right a high percentage of the time, the act of telling the student that he is

correct becomes a reward or reinforcement. Thus programs have a much higher amount of reward or reinforcement than most ordinary teaching situations.

4. The units are arranged in careful sequence. Because the subject matter is broken into small bits, the author must think carefully about the learning steps involved, and the result is a much better sequence of presentation. Careful sequence also embodies the notion of shaping or gradually leading the student toward the desired goals by rewarding him for activity that more and more closely approximates those goals.

5. Programs are aimed at specific goals. This has the desirable effect of making those involved in training evaluate their goals much more carefully and specifically.

6. Revisions are based on student responses. Because the student's behavior can be recorded for each frame, a knowledge of his understanding of each part of the lesson can be easily obtained. Thus, if a student is making many errors on one section, the program obviously is not teaching well and must

be revised. Here, then, is another cardinal principle of programming; namely, that the student is the final authority in determining whether or not the program is good. In traditional curriculum materials an "expert" often determines the final presentation, but in programming, the approach is more student-centered. Programs are also more carefully aimed at a particular ability-level of student, based on experimentation, not on opinion.

7. The student is usually free to vary his own rate of learning. A student may work through a program rapidly or slowly. He is completely independent of others in the class. Traditional methods such as lectures or motion pictures force every student to proceed at the same rate, which might be too fast for some and too slow for others.

Programs are usually divided into two main types, depending on the kind of response demanded of the student. The constructed-response type of program requires the student to write an answer to a question put before him by the programmer. (See Figure 1) The multiple-choice type of program requires the student to select one of a number of alternate answers to a given question. (See Figure 2) The constructed-response program asks the student to frame his own answer to an "open-ended" question: the multiple-choice programs ask for a choice among alternate answers. The former clearly depends more upon the student's ability to recall data; the latter, on the ability to recognize it.

There are two major techniques for programming sequences that are currently widely used. In one case, the material is arranged in a single-ordered sequence and every student must proceed from

the first through the last item. This is known as linear programming. In other cases, more than one sequence or route through the material is arranged, the the student follows the sequence determined by his own answers. For example, a correct response to one question may lead down a route that skips several questions, while an incorrect reply produces a route on which each of these questions must be answered. This practice of providing alternate routes through the program is called branching.

COMPARATIVE RESEARCH

If one were to search the literature to answer our question, "How effective is programmed instruction in the teaching of reading?" he would be hard put to find much serious research bearing directly on this question. In fact, since this question remains pretty much unanswered, I think that the best thing to do is to go back to my presentation of last year in which I stated that the biggest and best controlled study on teaching of reading by programmed instruction was done by Ruddell which was one of the U.S.O.E. sponsored first-grade studies (7) (14). Ruddell was really interested in seeing if certain linguistic-type supplements to both basal reading texts and programmed reading books would aid in reading instruction, but he also included in his study one group of classrooms which used the Sheldon Basic Readers and another set of classrooms which used

the programmed reading series by Sullivan and Associates. (See Figure 1) By looking at Table 1 we can see that there really isn't much difference between reading achievement scores at the end of first grade in the two groups.

A small study was done by Bannatyne at the Word Blind Study for Dyslexic Children in London using linear programs to teach punctuation and time telling (1). These children were matched on age, sex and non-verbal ability and reading age (the lowest reading age was 7.0). Bannatyne found that both the teaching machine group and the orthodox teaching group gained significant knowledge but that "it can be concluded that within the limits of this experiment, teaching machines teach second year junior children no better or worse than teachers in an orthodox teaching situation."

In a master thesis study done by Siegler in 1967 an attempt was made to measure growth in reading of 36 mildly remedial high school readers. After nine 45 minute sessions using the Lessons for Self Instruction Basic Skills (See Figure 2), students had lost a tenth of a year in scores on the Gates Reading Survey between Form 1 and Form 2. I cite this study not to show that you go backwards using programmed instruction but rather some of the methodological flaws

and difficulties in trying to measure gains on programmed instruction. In this study we had a short training time coupled with an insensitive instrument. The Gates Reading Survey is a good gross screening device,but with a range of third grade through tenth grade in 21 items of the comprehension test,you don't get much reliability.

When studies had been done in other subject matter areas in which the exact same content had been programmed and presented in text form, we often see little difference (5) (13). My last year's paper before the IRA reported some summaries of other studies with positive and no-difference results (7). It is difficult to find studies with negative results as the investigators tend not to write up failures (assumming they are interested in the "experimental method"), but we have one near admission in a project done in the New York City Schools.

> "Gotkin and others became involved with this population in 1963 in the Reading Improvement Project of the Center for Programmed Instruction. During the two years with this project, they wrote and tested programmed instruction lessons directed at teaching a number of skills designed to upgrade the reading ability and subject-matter vocabulary of seventh and eighth graders who were reading at the fourth grade level. In terms of the goals of the project they failed to produce a significant amount of programmed materials capable of modifying the critical aspects of the reading behavior of their target population." (9)

Even though the effectiveness of programmed instruction over conventional methods is yet to be demonstrated, there has been some interesting research on parts of the programmed learning process. Gillooly in 1968 has shown after a review of his own and other studies, that if you expect to have the student learn to make constructed responses (the criterion task of writing the answer) then you must train him with a constructed-response-type program, but if the student is only expected to make a selection of multiple choices, then training on a multiple choice program is satisfactory. (8) This superiority of constructed responses is particularly important in teaching of novel terms. Reading teachers might make use of this information by providing ample experiences of writing words in vocabulary lessons.

A HISTORICAL VIEW

What then keeps programmed instruction alive? Part of the answer might be found in ancient dreams. Dale in his article "Historical Setting of Programs" in the 1967 NSSE Yearbook cites an interesting passage from Edward Thorndike written in 1912 giving us almost a prescription for programmed books: (3)

> "Books could be written giving data, directions for experiments and problems with the data, and questions about the inferences. The students could be instructed to read each helping piece of information, suggest questions and the like only after he had spent a certain amount of time in trying to do for himself what he was directed to do...if by a miracle of mechanical ingenuity a book could be so arranged that only to him that had done what was directed on page 1, would page 2 become visible and so on. Much that now requires personal instruction could be managed by print."

Thorndike then went on to give a classic argument for automation: "A human being should not be wasted in doing what 40 sheets of paper or 2 phonographs could do." Dale then discussed the similarity between some modern programmed instruction books and the catechism-type of question and answ books used by the ancient Greeks.

For anyone who has studied a history of education, it becomes harder and harder to see "new" ideas. The stress on clear educational objectives did not begin with Skinner or even Mager. A decade earlier, Bloom and Krathwohl were carrying the banner and before them were Tyler and Charters. This notion of clarifying educational objectives also stretches back to the Greeks and probably before them if we had any literature on pedagogy.

Programmed instruction seems to have burst upon us in relative recent times, but it has had an uncertain and unsteady progress. Since Pressey first published his article in 1926 very few other works were done in the area of teaching machines or programmed instruction, with the exception of a few of his students. The present cycle of activity began in 1954 with Skinner's article and interest in teaching machines and programmed learning seems to have reached some kind of peak about 1963.

Corey in his 1967 NSSE article has given us a good index of activity by simply counting the number of entries in the Educational Index for two-year periods beginning in 1959. (2) He carried his count through 1965 and I extended two more years. We find that by combining the two subject matter headings of Programmed Teaching and Teaching Machines, that in 1959-61 there were 130 articles. In a two-year period of 1961-63 there were 440 articles. This has steadily declined and in the 1963-65 period there were 342 articles but during 1965-67 the number had dropped to 232. (See Table 2) I even found a drop between the one-year period of 1965-66 and 1966-67. Corey found a similar curve in entries in the Psychological Abstracts with the peak year being 1964. I found a similar though later curve in the Subject Guide

to Books in Print, U.S.A. issues of 1966 and 1967 (See Figure 3). The list of Reading Programmed Learning materials in Textbooks in Print showed no change between the years 1967 and 1968; there were 8 series or individual programs (See Figure 4). A larger number of programs, many from small publishing houses, can be found in Programmed Instruction Guide, compiled by Northeastern University. (18)

Yet with all of these articles, the lack of evidence about the effectiveness of programmed instruction, particularly in the field of reading, is striking. Silverman was able to write a whole chapter entitled, "Reading and Related Verbal Learning" in the NEA sponsored book Teaching Machines and Programmed Learning II without getting down to the comparison or effectiveness problem. (16) The National Society for the Study of Education put out an entire yearbook called Programmed Instruction in 1967 which has very little about the effectiveness of programmed instruction and nothing about the effectiveness of reading instruction. The NSSE Yearbook in the following year, 1968, put out a volume on reading entitled Innovation and Change in Reading Instruction in which programmed instruction was mentioned by the authors; none of them gave any data as to its effectiveness. (12)

Publishers have some glowing testimonials and even quotes of small unpublished studies, but in the regular literature,

there is very little. Perhaps it is unfair to ask this of programmed instruction when we do not ask it of basal texts or supplementary instructional materials. But programmed instruction was born in the psychological laboratories where testing is the order of the day and somehow most of us had greater expectations for its empirical justification.

PROGRAMMED INSTRUCTION USE IN INDUSTRY GREATER THAN SCHOOLS

There is some evidence and a widespread feeling that programmed instruction is used more widely in industry than in the public schools. As evidence of this, one need only look at the membership of The National Society of Programmed Instruction which is the major professional organization in the field, and the type of articles published in their journal. (11) On the other hand, the Center for Programmed Instruction, which was largely education-oriented, merged into Columbia Teachers College and has more or less disappeared. A similar loss of educational interest is reflected in the program and journal articles of the Division of Audio-Visual Instruction of NEA.

I have wondered about the greater percentage of use of programmed instruction and the greater continuation of use in

industry than in the schools and would like to offer the following reasons:

1. Training objectives are more limited and more specific.

   An airline is interested in having certain employees know how to read the weather code symbols, but in teaching about weather, a school doesn't know if it should stop at meteorology, physics, chemistry, industrial pollution or ecological effects once it starts talking about weather. Likewise the school feels that it has done a great job if a student starts reading about weather and gets a student to go on and learn about the influence of the moon on tides; but an industry has done a good training job if the employee learns the weather code quickly and gets back to work earning money for the company.

2. Industry has no vested interested in the status quo.

   If a school superintendent decided to temporarily place half his teachers into curriculum development and writing programs, this would mean that the other half would be teaching twice as many children. This situation would undoubtedly mean immediate dismissal of the superintendent; yet a training director in industry could make this kind of decision on Wednesday and have it implemented by the following Monday.

3. Industry typically has a much less stable student population. The public school principal knows within a couple of percentage points how many students will be at what stage of development a year or two in advance. In industry, model changes, market fluctuation, and technological advances all contribute to short term fluctuations. The training director may have 500 students attending classes one week and 1,000 the next. He may have some classes at 10:00 a.m. and some at 10:00 p.m. He may hold some classes for 25 employees at the home office and some for three students in Tulsa. In short, the flexibility to package up the training and ship it anywhere at any time for any amount of students is worth a lot more to industry than to the schools.

4. Trained teaching personnel is much more available in the schools than in industry. Even with long-term teacher shortages in the public schools, there is a much more readily available supply of trained personnel for public school teaching than any industry can muster. In industry, training is often done by supervisors who were trained primarily in work experience and who often view teaching as an unpleasant occasional necessity.

I don't wish to belabor the point of differences between industrial training and public schools, but it does tend to answer the question of "Why is more programmed instruction done in industry than in the schools?" It also points out the important "system" concept that any training method must be evaluated in light of the total training situation, and to simply ask "Does A teach better than B?" must be modified by a whole string of qualifications like who? when? and where?

THE EVALUATION PROBLEM

The whole problem of evaluation of curriculum materials or teaching methods is extremely important. Probably the best model of critical evaluation comes from the testing field where every published test is critically reviewed by experts in the field in Buros' Mental Measurements Yearbooks. But even this, as valuable as it is, falls short of empirical validation or comparison. In other words, the experts look at the tests and the manuals and make judgments based on experience or knowledge of testing. It would be more valuable if they or several independent sources did an item analysis, comparative validations and other statistical verification based on actual administration of the test to specific populations.

The reading field recently saw a major effort in comparative evaluation in the USOE sponsored First Grade Studies in which 27 independent investigators tried out two or more methods of teaching beginning reading on moderately large populations using the same reading tests as achievement measures. The Ruddell study mentioned earlier was the only one of these to use programmed instruction. I fervently hope that when money for educational research is again available, that not only will the First Grade studies be replicated, refined, and extended, but we will investigate upper levels of reading instruction in the same controlled objective manner.

Many members of the American Educational Research Association have long been concerned with comparative evaluation of teaching methods and materials. At their recent conference, February 1968, a major symposium was devoted to this topic and Louise Tyler presented a set of "Recommendations for Curriculum and Instruction Materials" which grew out of an ongoing project at the University of California at Los Angeles. These recommendations had much to say that bears on objective evaluation, not the least of which is the calling on publishers to produce a manual similar to a test manual which specifies not only objectives, but such evaluation procedures as: (17)

E2 Manuals should clearly distinguish between kinds of evidence presented about effectiveness:

(a) internal evidence
(b) external evidence

Internal refers to features that can be revealed through visual inspection of study of materials. External refers to tryouts, revisions, etc.

# # #

E4 Effectiveness of programs should be reported in terms of program objectives as well as unintended outcomes.

# # #

E5 Curriculum and instruction materials should be evaluated in relation to different types of students, e.g., intellectual level, sex, age, socio-economic.

These lofty requests call to mind the efforts of the AERA-APA-DAVI Joint Committee on Programmed Instruction and Teaching Machines who issued the Recommendations for Reporting the Effectiveness of Programmed Instruction Materials. (10) These recommendations, like Tyler's, are essentially what the educational researchers and the better informed curriculum purchasers would like to have. However, no publisher has even come close to supplying the requests for the type of manual called for by either group. Perhaps someday professional organizations such as the IRA can arouse their membership into demanding that publishers pro-

duce such manuals to accompany instructional materials or else they will refuse to purchase. It is a little unrealistic to expect publishers to start publishing these expensive manuals if they don't have to or, I might add, if nobody is willing to pay for them.

CONCLUSION

In returning to our original topic, "How effective is Programmed Instruction in Teaching Reading?", I am reminded of an incident several years ago in which I was discussing a report on educational television with a prominent educator. The educator said after looking at numerous tables and graphs, "Well, TV's no more effective than an ordinary classroom teacher." He could have even justified the statement by saying there's no statistically significant difference between children taught by a teacher and those taught by instructional television. The significance, however, was not of the .01 or the .05 nature, rather it had an entirely different sort of significance in which, with educational television, we had one teacher teaching a hundred thousand children as opposed to the ordinary classroom teacher who taught 30.

I am not proposing that programmed instruction is here to replace teachers, but we do have numerous studies which show that it does teach some things as well as a teacher, which means that the teacher can then do something else. For example, we can have no teacher or paraprofessionals doing part of the instruction while the teacher diagnoses a weakness or motivates an underachiever.

Somehow or other I can't believe that a method which incorporates such saintly goals as specifying objectives, allowing for individual differences in learning rate, allowing for great diversity of subject matter being taught (even if the teacher doesn't know the subject matter) and provides for student interest through a variety of instructional techniques, is going to be allowed to fade away completely. In fact, there's evidence that programmed instruction is being incorporated into the new supernova of Computer-Assisted Instruction and the minor novas of Individually Prescribed Instruction and the Systems Approach.

I expect that in a few years someone will be able to do an Education Index count of articles and show a rise and decline for CAI. But in the meantime, one of the units that is

rapidly becoming a staple in the teacher's bag of tricks is programmed instruction. I personally have learned a lot about teaching from studying teaching machines and programmed instruction. It has greatly influenced my thinking and outlook and I hope in some small way all of this plethora of article-writing activity has somehow helped that classroom teacher to do a better job with her children.

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18. _____Programmed Instruction Guide (compiled by Northeastern University), Newburyport, Massachusetts: Enteleck Inc., 1967.

Figure 1. Sample page from Programmed Reading Book 1, A Sullivan Associates Program. McGraw-Hill Book Company, 1963.

T

nap

This is a nap. / pan.

no

Nip

yes

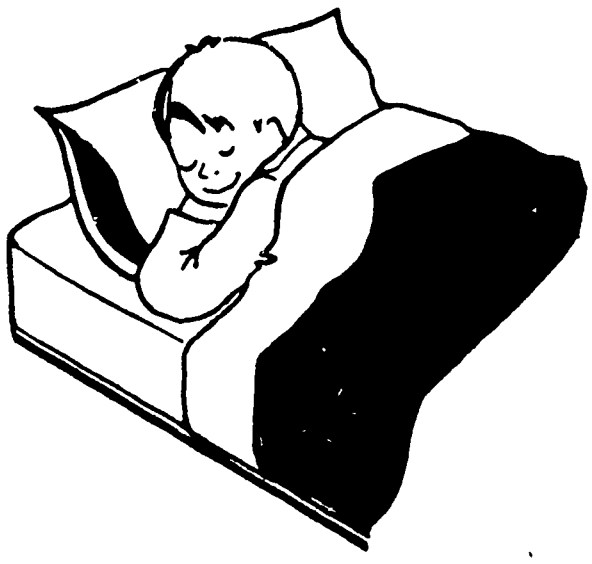
Is Nip singing? yes / no

N__p is napping.

yes

Is Tab napping? yes / no

yes



Can Sam nap? yes / no

Figure 2. Sample page from Following Directions, A Programmed Reading Study by Miles Midloch in the Lessons for Self Instruction Series, California Test Bureau, Monterey, California, 1963.

61 SAMPLE INITIAL FRAME

Mary Smith, studying for a test, had no time to go out for dinner. She took a packaged, precooked frozen chicken dinner from the refrigerator.

On the box she found these directions:

(1) Preheat oven to 400° (hot oven).

(2) Remove dinner from box.

(3) Do not remove or tear aluminum foil which should stay sealed to keep the steam and juices from drying out.

(4) Place dinner in preheated oven for 15 minutes, then remove it quickly.

(5) Fold back foil to expose chicken but not vegetable and potatoes.

(6) Return dinner to oven for another 10 minutes to complete cooking and brown the meat.

When Mary sat down to eat her dinner, she found that the chicken was pale outside and underdone inside. Did Mary omit any step? Did she follow directions in a wrong order? (Her oven was in good order. Whatever happened was Mary's fault.)

Mary omitted Step 2 of the directions. (No. 65)

She removed the foil before first putting the dinner into the oven. (No. 69)

Mary omitted Step 6 of the directions. (No. 73)

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62 SAMPLE WRONG RESPONSE FRAME

q

o

No. If q is over o in your code, something is wrong. Did you follow the directions given in No. 67 carefully? You did not! An important part of it escaped you.

Return to No. 67 and read the directions again. Compare your code with each step of the directions.

Figure 3. Number and Date of Publication of Books on Programmed Instruction from Subject Guide to Books in Print U.S.A. 1966 and 1967.*

YEAR	1	2	3	4	5	6	7	8
1960**								
1961	X	X						
1962	X	X	X	X	X	X		
1963	X	X						
1964	X	X	X	X	X	X		
1965	X	X	X	X	X	X		
1966	X	X	X	X	X			
1967	X							

* These are books about programmed instruction.

** No books listed prior to 1961.

Figure 4. List of Reading Programmed Learning Materials in Textbooks in Print 1968*

1. Allen, R. V. & Claryce. Language experiences in reading, levels 1-3, gr. k-3, 1967, EBE Corp.

2. Educational Development Corp. By Myself Series for Ginn basic readers, 1963, Ginn.

3. Bostwick, Gracecarol & Miles Midloch. Lessons for Self Instruction in Basic Skills, 1964-1966, Cal Test/McGraw-Hill.

4. Carroll, Luch. Programmed phonics, 1966,,Educ. Pub.

5. Educational Development Corp. Help yourself to read, write, and spell, 1966, Ginn.

6. Glassman, J. Programmed reading, 1966, Globe.

7. Loretan, Joseph O. and New York City Schools staff. Building reading power, 1964, Merrill.

8. Sullivan Associates. Programmed reading ser. gr. 1-3, 1963-1965, Webster/McGraw-Hill.

*Category 141 Readers and Category 142 Reading Skills Under Programmed Learning. Materials show no increase or decrease from 1967. These are programmed materials for students.

TABLE 1

PROGRAMMED READING COMPARED WITH BASAL READERS AT THE END OF 1st GRADE

(Data taken from Ruddell 1965)

Group Reading Test Means	Buchanan Programmed Reading	Sheldon Basic Readers
Stanford Achievement Test Primary I (N=about 132 per cell) Grade Scores		
Paragraph Meaning	1.6	1.7
Word Reading	1.8	1.7*
Word Study Skills	1.7	1.7
Spelling	1.7	1.7
Individual Reading Test Means		
Raw Scores (N=about 44 per cell)		
Gilmore Oral Accuracy	16.6	17.7
Gilmore Oral Rate	46.8	51.8
Gates Word - Oral (Words not selected for phonic regularity)	11.8	10.8
Phonetically Regular Words Oral Reading Test	9.1	5.4*

*Ruddell found raw scores with statistically significant differences between means at .05 level.

Table 2

Number of Entries in Education Index, 1959-67*

Year	Programmed Teaching	Teaching Machines	TOTAL
July, 1959-June, 1961	51	79	130
July, 1961-June, 1963	321	119	440
July, 1963-June, 1965	313	29	342
July, 1965-June, 1967	186	46	232

*Adapted from Corey (2) and extended by Fry